Chapter 1
Soundscape: The Development of a New Discipline

Brigitte Schulte-Fortkamp and André Fiebig

Abstract The concept of soundscape as a paradigm shift for understanding, measuring, and analyzing environmental sound is more than 50 years old. Many disciplines have adapted the soundscape concept and approach to study the impact of sound on humans (and animals) more holistically with perception gaining increased significance. In the beginning there were inconsistent applications of soundscape concepts, ambiguous soundscape definitions, and multiple understandings of the appropriate approach to study soundscapes, which impeded progress. Consequently, the need for a certain level of consensus across disciplines and professions was recognized and terms, methods, and analyses were internationally standardized, leading to more consistent research endeavors. With international standards and established procedures, the field of soundscape research continues to move beyond the use of simple standards and technical specifications. More than ever, soundscape research is performed to understand more deeply the impact of sound on humans in specific contexts. With this approach, humans are acknowledged to be more than passive receivers of their acoustic environments; rather, humans interact with their environments as both creators and receivers of the soundscapes. This perspective on interrelationships between person, activity, and place has led to substantial research efforts that continue to yield valuable insights into understanding soundscape.

Keywords Soundscape · Health · Social aspects · Community noise · Urban planning

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B. Schulte-Fortkamp et al. (eds.), *Soundscapes: Humans and Their Acoustic Environment*, Springer Handbook of Auditory Research 76,
https://doi.org/10.1007/978-3-031-22779-0_1

1.1 Introduction

The soundscape is a relatively recent concept applied to the methods used to evaluate acoustic environments. For decades, noise control was based on measurements that were intended to reduce the burden of noise but were never really successful. Noise reduction was done at the sources and through regulations about road traffic, train, and airplane noise based on noise levels. Schultz (1978) stated that people were not satisfied with those measurements because they still felt burdened by the reduced noise.

1.1.1 What Is Soundscape?

Soundscape refers to the perceptual construct of the (acoustic) environment; the acoustic environment represents sound at certain locations as described by physics. Because the soundscape describes the perception of the acoustic environment, efforts continue to focus on developing reliable methods that quantify the perception of complex environments for humans and animals in more detail.

1.1.2 Purpose of this Volume

Soundscape is playing an emergent role when and wherever society gathers, which simply means everywhere. Therefore, multiple disciplines have adopted the soundscape concept to study the impact of anthropogenic sounds (or animal sounds) in all kinds of environments, in various contexts, and from different points of view. Even new disciplines have emerged to bridge intersectoral barriers and overcome disciplinary borders. In particular, the concept of soundscape has gained ground in the fields of urban sound, community noise, and environmental noise control (To et al. 2018).

This book is an introduction to the field of soundscape research. The chapters provide discussions of how soundscape research can enhance the quality of life about the acoustic environment for humans and non-humans as well. The chapters bring together broad ideas on soundscape to enhance understanding and provide insight into the major considerations for how soundscape is studied and how it impacts humans. Each chapter refers to soundscape within the definition “acoustic environment as perceived or experienced and/or understood by a person or people, in context” (ISO 12913-1 2014), including an introduction to the variety of soundscapes in different areas. The concept of soundscape includes all the sounds in one’s environment, but the focus of research relies primarily on evaluating human perceptions and the interrelationships between persons, activities, and places in both space

and time. Understanding soundscape will provide a greater appreciation for the diversity of acoustic environments and their effects on people.

Soundscape is not only related to humans but to animals as well. The quality of the soundscape is as important for their health and well-being as for humans. (e.g., Slabbekoorn 2018; Derryberry et al. 2020). While this book focuses on the human soundscape, many of the ideas and principles that are discussed are equally valid for both terrestrial and aquatic animals, and so those interested in other animal groups will benefit from the research perspectives provided in these chapters.

1.1.3 Soundscape Research Priorities

The concept of soundscape integrates individuals into the process of assessing and changing acoustic environments based on the perceptions and responses of affected individuals. In addition, the study of soundscape changes the research priorities: perception is assessed first and then acoustical measurements are made if needed for a deeper understanding of variables in the environment. Basically, a soundscape is clearly distinguished from the acoustic environment.

The environments that are subject to soundscape studies vary widely, from natural areas (e.g., woods, oceans) to urban areas (small cities, major cities). Although traditional environmental and community noise assessments still rely heavily on sound pressure level (SPL) indicators to quantify noise exposure, predict noise annoyance, and derive noise effects, it is increasingly apparent that a sound level-oriented perspective cannot capture several relevant aspects of noise and its perception in specific contexts. Thus, methods have been developed to measure and analyze human perception of sound in context. The discipline of environmental psychology evaluates the perception following common principles and rules that possess an inherent logic. Explorations of those principles and rules continue to be subjects of active research.

Schafer (1977) introduced his concept of soundscape from a musical point of view, and this new way of dealing with and understanding environmental noise was adopted by many others. In the 1990s, Schafer's concept was increasingly discussed and extended scientifically. That scientific discourse of the soundscape concept led to the development of advanced methods and tools to systematically collect soundscape-related data that resulted in international standardization efforts, which ultimately led to a broader dissemination of the soundscape concept.

Human perception of noise is influenced by several factors. In complex environments, humans usually recognize patterns out of sensations by using mediational processes to put together diverse sensations. The recognition of patterns constitutes perception and represents the perceptual construction of the external world. In general, the apparent link between a noise stimulus that causes a physiological reaction (an auditory sensation) that is cognitively processed as a perception (a hearing event) can be altered by numerous effects. For example, stimulation of another sensory system concurrently can modify the percept of sound in remarkable ways. The

assigned meaning to sound can influence human sound perception as well and, most likely, the relative quality of the auditory sensation.

1.1.4 Sound Versus Noise

"Whenever society happens there is sound" (Maeder 2013, p. 424). Acoustic environments are full of sound sources that specifically shape the environment. In general, when we think about an acoustic environment, we refer to noise. Noise has many faces: it is any unwanted sound that is disturbing and can be violating when extreme. Achieving environmental quietness seems to be a frequently stated goal, but the question is whether a quiet environment is a good acoustic environment? What makes a good acoustic environment, and is there a common understanding of an acoustic environment that is good?

More and more people are living in highly dense cities, often packed in high rise buildings positioned between commercial activity and high amounts of all kinds of traffic. Schafer (1977) described this process of increasing urbanization in the 1970s as towns have grown into cities, and cities have expanded to cover much of what was formerly rural land. This development leads to many challenges, including social conflicts, environmental impacts, and the problems caused by noise. For years when people complained about noise, the reaction was to measure the noise physically in terms of basic level indicators, which did not provide insight into the actual details of noise that burdened the local population. A different approach is taken in soundscape research and data analyses.

Today's permanent technological changes at sources lead to the expectation that reduction of noise at the source will make the living environments become quieter. Yet, the opposite is the case: due to increasing traffic volume, increasing noise is the daily experience. Therefore, a different structure of urban areas may change the burden of noise. Eventually, adding more green areas, designating more pedestrian zones, and reducing the use of personal cars to use public transportation may lead to a new acoustics in urban environments.

For many years, transportation noise from diverse sources has been considered to be a type of environmental pollution that affects human health and well-being. Numerous studies determined limit values that, when exceeded, increased the risk for certain adverse health effects. These limit values were identified for each source separately as the relationship between response and SPL varies significantly from source to source (WHO 2018). As important as those health-related studies for effective health protection are, the rich and multidimensional experience of acoustic environments is not sufficiently covered by those simplified exposure-response perspectives that consider the impact of annoyance and sleep disturbance from only single sources. Acoustic environments are usually full of contrasting sound sources that shape the environment in site-specific ways.

Humans living in cities are not exposed separately to each unwanted source. They are exposed to an acoustic environment created by the complex superposition

of several sound sources. Those acoustic environments can elicit numerous sensations and emotions that are not limited to annoyance. Moreover, certain sound sources cannot be described as more or less annoying and disturbing because they can be perceived as pleasant or promoting a feeling of restoration and relaxation. In addition, specific places (e.g., parks) and contexts (e.g., a Sunday afternoon) in which sounds are perceived can modify the response to an acoustic environment.

Studies of acoustic environments should be always related to quality of life that includes understanding human perception, experience, and expectations. If humans are perceiving and considering their acoustic environments, they are also cognizant of the overall "gestalt" of all sensory components of that environment. From Schafer (1977) we learn that acoustic environments must also be understood as resources for social life.

To understand the complex perception of acoustic environments more comprehensively, it is necessary to go beyond statistical considerations of dose (in terms of level) and response (in terms of the degree of annoyance) functions. The expertise of the population concerned is required to identify location-specific peculiarities. Obviously, popular places and parks in cities often aren't quiet. Nature settings appraised by most people for their recreational and restorative potential are not necessarily silent, for example, coastal sites with the sounds of ocean waves or sites with frequent bird calls.

A quiet and calm outdoor area implies a pleasant soundscape where people enjoy staying for a while (Salomons et al. 2013). Birdsong or water features improve the perception of an urban soundscape (Galbrun and Ali 2012; Zhao et al. 2020). Greenery and vegetation also can improve the perception of environmental noise and often outperform conventional noise mitigation measures. For example, based on quantitative estimates by van Renterghem (2019), the equivalent level reduction with (high quality) visible greenery from home could reach −10 dB(A), which is in addition to any physical SPL reduction one might obtain behind vegetation belts.

The COVID-19 pandemic of the 2020s revealed how the acoustic environment around the world could be affected by a reduction in human activities. Significant changes in soundscape happened at different scales (Aletta et al. 2020), and those changes affected a broad range of sites, including historic soundscapes and heritage sites that attract locals and tourist populations as documented by Jordan and Fiebig (2021). This sudden change in human activities showed that a broad approach is needed to study environmental noise and noise protection cannot be isolated from social context and changes in human behaviors.

1.1.5 The Soundscape Approach

Some understand soundscape as a kind of "umbrella term" for a more comprehensive way of assessing noise that is more related to the respective context. This understanding comes along with varying definitions and notions that depend on the research discipline, which shapes how the term is applied. Although there was, and

still is, a broad variety of meanings attributed to the term soundscape, the motivation to create the term seems clear. Noise needs to be studied for its complex effect on humans and animals. Following a negative approach and dealing with noise simply as pollution is too narrow (Schafer 1977).

Schafer (1977) wanted to treat the world as a macrocosmic musical composition. This simple idea triggered numerous applications and paradigm shifts in different scientific fields and disciplines. Schafer wondered about the dominance of visual culture and the loss of sonological competence within modern societies. One of his prominent techniques for understanding a sonic environment was the development of the so-called Isobel maps, as shown by his log notes of sound events during a full day in the countryside of British Columbia, Canada (Fig. 1.1). The field study included SPL measurements and the description of a wide range of sonic features (Truax 1978). According to Maeder (2013), the Isobel map holds differentiating information about the distribution of acoustic intensity and looks very similar to a geographic map produced with elevation contour lines. Decades later, noise mapping is a major issue regarding community noise and is part of the European Directive on Noise (END 2002).

Schafer's research strategies led to his classification of "hi-fi" and "lo-fi" soundscapes. A hi-fi environment is one in which sounds may be heard clearly without crowding or masking. Even sounds in the distance can be heard. In contrast, a lo-fi soundscape indicates that an environment is overcrowded with keynote sounds and signals that result in masking or lack of clarity for individual sounds. The listener cannot separate the different sound sources and cannot detect any sound events in the distance anymore (Schafer 1977). Such a qualitative understanding of an

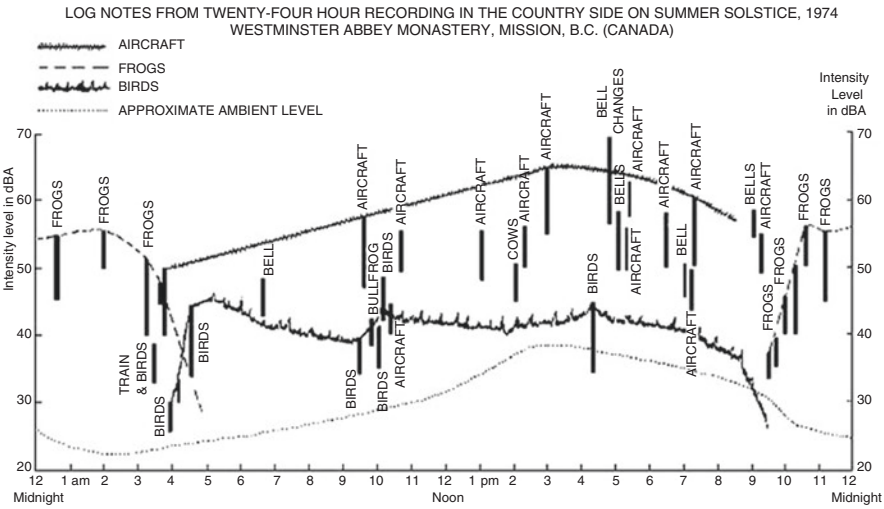

Fig. 1.1 Schafer's short log notes of sound events taken during a 24-hour period in the countryside in British Columbia (Schafer 1977, p. 266)

acoustic environment may seem elitist, but such simple classifications may help to solve difficulties in assessing acoustic environments for enhancing quality of life.

In 1984, the Institute of Kanda was founded in Tokyo, Japan, by Keiko Torigoe and her colleagues to establish research in soundscapes (Hiramatsu 2006). They followed the understanding that fieldwork must be conducted under the subjective local view within the respective acoustic environment. According to Hiramatsu (2006), the concept of soundscape was also subject to contributions from musicologists, sociologists, philosophers of aesthetics, and environmental scientists reaching out for designing public gardens. Soundscape studies in Japan started with "fieldwork in urban areas than proceeded to soundscape design. […] soundscape studies […] are more or less related to the sonic environment with emphasis on the way it is perceived or understood by individual or by society" (Hiramatsu 2006, p. 863).

For example, the Yamahoko-cho area located in the city center of Kyoto is famous for the Gion Festival, which is one of the biggest and oldest festivals in Japan. Each year in July the ceremony and festival are undertaken for one month, and the soundscape in the city becomes dominated by a variety of sounds related to the festival. According to Hiramatsu (2000), the music is accepted as a characteristic of the city and, though the music is without any doubts the loudest sound ever heard in this area, there are no complaints.

Similar findings were reported from an Italian research study related to the Gigli di Nola folk ceremony in the little town Nola near Naples in Italy, which features a shoulder-borne procession celebrating the feast of Saint Paulinus. Alves et al. (2021) examined how the physical and spatial arrangement of Nola shaped the enactment of the festival's soundscape, atmosphere, and the behavior of its participants. They found that the procession soundscape dominated the atmosphere of the festival, and that the rhythmic qualities guided the parade for the participants at the Gigli festival. The soundscape analysis was an indicator of the value of the acoustic components in the festival.

Indeed, human perception is an important and firsthand measure for decisions about any assessments, initiatives for changes, or further development. Moreover, physical measurements play a different role compared to such measurements in noise research. In soundscape studies, physical measurements should be considered only as a follow-up to the analysis of perceptual evaluations.

Measuring individual perceptions with soundwalking and related procedures have become especially important methods (see Brambilla and Fiebig, Chap. 7). A perfect example for this procedure is the Nauener Platz project in Berlin. Through the systematic application of the soundscape process, a solution was found to change a public place suffering with acoustic and social problems into a place of social communication, relaxation, and safety that is well-accepted by the people living in the surrounding area (see Schulte-Fortkamp and Jordan, Chap. 3 and Fiebig and Schulte-Fortkamp, Chap. 11).

1.2 Measures and Measurements in Soundscape

Over time, there has been an increase in the demand for the soundscape approach for planning in urban areas. Based on the successes seen in soundscape research, the involvement and participation of people as local experts help to support the success of intended changes (de Coensel et al. 2010, 2017). The soundscape procedure gives the same level of relevance to people's thoughts and feelings as to physical measurements. These complementary methods have been codified in the standardization process.

The standardization process for soundscape (ISO 12913 series) helps researchers make the best methodological decisions for the soundscape measurement needed to support individual participation as a basic component in strategic planning for an acceptable acoustic living environment (see Schulte-Fortkamp and Jordan, Chap. 3). In addition to providing definitions and a conceptual framework, the soundscape standard offers appropriate measurements for soundscapes and analysis tools to be used for any activity considered in a soundscape.

The soundscape of a classroom (Brill et al. 2018) and restaurant (Roy and Siebein 2019) may use the participation of people concerned with the description and analysis of the space, but there is a further issue that counts: the context. Another example (Schulte-Fortkamp et al. 2007; Brooks et al. 2014) is the planning process for a public space where both residents and visitors will be involved as the understanding of any intervention will be different for these two groups who would participate in the process.

1.2.1 Context

The importance of context in a soundscape is described in the ISO 12913-1 (2014). Context is defined there as the physical place where the acoustic environment exists. Contextual studies consider the interrelationships between person, activity, and place in space and time. Consequently, the context may influence soundscape due to what is heard, the interpretations of those auditory sensations, and the responses to that acoustic environment (Kang et al. 2016). Included in context is the meaning of the specific place to the individuals involved and its use by those individuals.

Other factors can influence the auditory sensation in addition to the acoustic environment: visual impressions, scents or odors, time of day, lighting, meteorological conditions that vary seasonally, and even individual hearing impairments and hearing aids (ISO 12913-1 2014). The interpretation of auditory sensation can be influenced by the specific sound sources, previous experiences with those sources, and individual expectations that include intended use of a space. Expectations can also vary with cultural background, personal activity preferences, and individual capacities to deal with variable situations (see ISO 12913-1 2014).

1.2.2 Acoustic Measurements

Classical noise control solely relies on the measurement of loudness determined in terms of SPL indicators like the energy equivalent sound pressure level (L_{Aeq}) or the day-evening-night level (L_{DEN}). The general understanding is that the higher the level, the more annoying the environmental noise should be. In some cases, the SPL alone is not sufficient to predict accurately the human response to an unwanted sound (noise) source. The concept of "rating level" L_r was introduced to correct the physical level value by bonuses or penalties to predict noise annoyance more reliably. For example, sounds from unwanted sources with prominent tonal components are more annoying than sounds without prominent tones at the same SPL. Thus, simply a correction by a few dB, called the tone penalty, is applied to adjust the rating level to indicate the resulting noise annoyance properly.

In the context of soundscape, a simple link between SPL and annoyance is not assumed as sound is understood as a potential resource that can be beneficial. For example, the pleasantness of wanted sounds cannot be determined by loudness measures or the annoyance from particular music cannot be measured solely by the magnitude of its tonal components.

In contrast to the basic concept of noise control and noise abatement that is aiming to reduce the SPL, Schafer (1977) defined a different approach that focused on interventions that cannot be described simply by the magnitude of level reduction. The notion of the soundscape concept is that there is no assumption that the sounds that constitute the acoustic environment must be of low intensity (Brown et al. 2011). This fundamental difference has also had a significant effect on the way acoustic environments have to be measured, characterized, and analyzed. Schafer (1977) proposed the use of both acoustics and psychoacoustics to learn about the physical properties of sound and the way that sound is perceived and interpreted by the human brain. Therefore, acoustic measurements and analyses must strive for a more sophisticated characterization of the properties of the acoustic environment and their relationship to perception.

1.2.3 Measuring Human Perception

When considering the focus on perception in soundscape, any recording method must consider the way humans perceive the acoustic environment. In addition to established binaural measurement systems, which are the most used recording techniques for soundscape studies (Hong et al. 2017), other recording technologies (e.g., microphone arrays) are frequently used in soundscape investigations as well. Those measurement systems strive for a playback based on multi-loudspeaker arrays that should provide a good level of immersion (ISO 12913-2 2018). However,

as those systems lack international standards, the comparability of acoustic analyses based on microphone arrays and ambisonics are limited (see Brambilla and Fiebig, Chap. 7).

Psychoacoustic and other perception-related parameters are measured and analyzed to describe the acoustic environment. The emotions and feelings elicited are measured by questionnaires that assign descriptive terms for the perception of the acoustic environment in all facets beyond the degree of annoyance (see Brambilla and Fiebig, Chap. 7). The approach to measure sound as perceived by humans led to increased attention to multiple parameters in psychoacoustic measurements within the realm of soundscape research since the early 2000s (Engel et al. 2021). Consequently, the ISO/TS 12913-3 (2019) called for consideration of binaural data analysis that include psychoacoustic indicators to enable the quantification of the acoustical impact on the listener and the exploration of relationships between physical properties of the environments and human response behavior. Other perception-related indicators considered range from eco-acoustic indices (Lawrence et al. 2022) to Mel Frequency Cepstral Coefficients (MFCC) based indicators (Lunden et al. 2016) to the second derivative of specific time and frequency parameters (Aumond et al. 2017).

Currently, searches for meaningful physical parameters are supported by machine learning and neural network approaches to predict human perception more reliably (e.g., Verma et al. 2019; Quinn et al. 2022). However, as the complexity of human perception seems almost infinite and is influenced by many intrinsic and extrinsic factors, the hunt for the most powerful (psycho)acoustic indicators will continue for a long time. For example, how humans make assessments based on bounded affective episodes is still not well understood; the nature of cognitive heuristic or normative operations converting patterns of experiences into overall assessments is surprisingly unclear (Fiebig 2019).

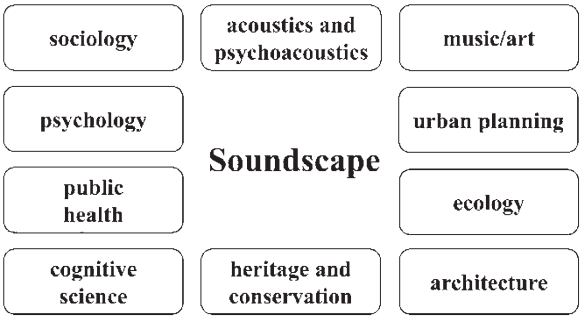

Fig. 1.2 Overview of disciplines dealing with the concept of soundscape from different points of view

1.3 Disciplines Using Soundscape Methods

The concept of soundscape is applied in several contexts and disciplines as illustrated in Fig. 1.2. Applications range widely from underwater acoustics and bioacoustics that are used for environmental noise assessments and acoustic ecology to terrestrial designs for sound art and meditation, but soundscape methods can also be applied to other areas such as sociology, psychology, and public health. The scientific rigor and the fundamental theories underlying the use of soundscape analyses in those areas have basic differences. For example, in underwater acoustics the term soundscape is used as a "characterization of the ambient sound […] in terms of its spatial, temporal and frequency attributes, and the types of sources contributing to the sound field" (ISO 18405 2017).

The first part of the soundscape standard ISO 12913 became available in 2014 and influenced research thereafter. However, in 2020, the use of soundscape standards was limited by the worldwide COVID-19 pandemic, which stopped many projects and initiatives in soundscape. However, in 2022, we have found new approaches in urban planning that are integrating the soundscape approach.

Di Loreto et al. (2022) found that the soundscape approach enabled a determination of the connections between the sensations of human beings and the environment during the planning phase of new attractions for an urban environment. This goes along with earlier findings by De Coensel et al. (2017) and Sun et al. (2018, 2019). When De Coensel (2017) was carrying out *The Urban Soundscapes of the World Project*, he stated that designing urban acoustic environments is a considerable challenge, especially regarding adequate measurements and data collection for architects who still work by example.

1.3.1 Eco-Acoustics

In the context of soundscape ecology, sound is considered from an ecological perspective, investigating natural and anthropogenic sounds and their relationships with the environment over multiple scales of time and space (Farina and Gage 2017). The discipline of eco-acoustics comprises the study of populations, communities, ecosystems, landscapes, and biotic regions of the earth, including terrestrial, freshwater, and marine systems. Thus, according to Farina and Gage (2017), eco-acoustics extends the scope of acoustic investigations by including bioacoustics and soundscape ecology.

Clearly, when disciplines relate their research to soundscape, the approach is influenced by evaluation procedures that rely on perception (see Fiebig, Chap. 2). In sociology and psychology, the impact is given through qualitative research with narrative interviews (Hollstein 2011). According to Knoblauch (2013), the field of sound studies was largely ignored in qualitative research in sociology. Nevertheless, there are first steps for culture studies that show how the tunes of the world are

analytically transformed into the sounds in and of society (Maeder 2013). However, soundscape research uses the soundwalk procedure (Sect. 1.3.2) as a qualitative research segment (ISO/TS 19123-2 2018).

1.3.2 Soundwalks

In the context of the typical application, the soundwalk method is used to collect context-sensitive data, environmental noise assessment, and urban planning. The soundwalk method is defined as a method that implies a walk in an area with a focus on listening to the acoustic environment (ISO/TS 12913-2 2018). Moreover, the input of local experts is expected in those evaluation procedures. A local expert is a person who is familiar with the area under scrutiny through either living in the area or having daily routines related to the area (ISO/TS 12913-2 2018). Here, the implication of "expertise" is connected to daily experiences and collected knowledge about an acoustic environment. "Local experts are those people […] who provide their expertise to researchers, investigators, and project designers through such processes as soundwalks and open interviews […]. The experience considers all conscious and unconscious influences sound makes in people's minds as they judge the appropriateness of sounds, sound sources, places, or situations." (ISO/TS 12913-2 2018, p. 14).

This appreciation of local knowledge led to more work on participatory approaches for which interventions and design options have been developed in cooperation with local experts and other stakeholders (Maag and Munck-Petersen 2018). The identification of environmental acoustic issues that need to be considered calls for collaborations with citizens as co-specifiers of projects (Xiao et al. 2017). For example, locals can be involved in participatory noise monitoring, empowering them to actively participate in improving their living environment by creating smartphone-based participatory soundscape maps (Brambilla and Pedrielli 2020).

As use of the place, the context, and expectations of its users is important to how the sound environment is perceived, local expertise must be involved in deciding what measures are appropriate and which characteristics require priority (Schulte-Fortkamp and Jordan 2016). The increasing interest in participatory approaches supported development of "co-creation concepts" and consideration of how those can be used in the context of environmental noise (van Renterghem et al. 2020). Botteldooren et al. (2020) envisioned that co-creation could go one step further to allow users of the space to augment the space with their own designs, and they concluded that co-creation opens a wealth of opportunities to improve public spaces and increase their use.

In any case, the paradigm shift in soundscape studies has occurred because everyone's experience is important and directly related to the area under scrutiny. However, it is essential that people are open for communication and willing to share their knowledge about a certain area. The ISO/TS 12913-2 (2018) provides methods

and procedures that guarantee the needed communication through questionnaires and guided interviews. Such data collection must capture the mood, restoration opportunities, individual appreciation of the space, individual preferences, and document overt behavior to create an accurate representation of a specific location. This type of evaluation, according to the ISO/TS 12913-2 (2018), shall respect the way people are experiencing their environment.

1.3.3 Architectural Applications

Important soundscape work is being accomplished in architecture (see Siebein and Siebein, Chap. 5). According to Brown et al. (2016), soundscape approaches can be applied to different places, such as malls and markets, transport stations, sports stadia, museums, and the balconies or terraces of our own dwellings. Indoor spaces can also benefit from the soundscape approach, for example, hospitals, educational institutions, restaurants, and homes.

Fowler (2015) criticized the traditional consideration of the acoustic environment within architectural design that focused mainly on concert halls or recording studios. He stated that any new approaches to auditory design in architectural practice must integrate critical listening as an important component. "To readily accommodate the acoustic impact of design decisions, particularly within a parametric paradigm, requires an immediacy between hearing the connection that visual form making has on the impact of the design's ability to communicate an intended acoustic signature. In such a framework, architecture gains the potential to become more than what is immediately seen and moreover, the case of whether sounds inhabit the space or space is produced by the sounds is a question only relevant to how one hears the design." (Fowler 2015, p. 70).

As discussed by Schafer (1977), studies in the arts, particularly in music, will support the creation of ideal soundscapes, especially when imagination and psychic reflection lay the foundation for a new interdisciplinary approach: the acoustic design (Schafer 1977). Work by Schulze (2019) on sound studies provided insight on a part of soundscape that is strongly related to art and music. Wondering about sound design and its function in the future, he presented a detailed overview of the modern history of sound design. In some cases, the creation of sound art and audio installations can meet urban sound planning and management expectations. In their sound art study, Steele et al. (2019) concluded that sound installations can change soundscape evaluations compared to the previous baseline condition; specifically, the installation increased calmness, provided a capacity for respite, and reduced the perceived overall sound level in the proximity of the (non-music) sound installation.

1.3.4 Roles of Soundscape in Human Health

The good practice guide on quiet areas of the European Environment Agency concluded that one should not focus on the quantitative health effects to be achieved, but instead one should offer people the opportunity to find calm (European Environment Agency 2014). It is necessary to know what makes an acoustic environment calming and restorative: we know that silence tends to frighten most people and the absence of unwanted sound does not automatically result in a pleasant soundscape (Nilsson and Berglund 2006).

Four different components have been considered important for creating a restorative environment, which underlines that restoration cannot be related only to low SPLs (Payne and Bruce 2019). Herranz-Pascual et al. (2019) observed that the soundscape characteristics that contributed to greater emotional restoration and a reduction in perceived stress were pleasantness, calm, fun, and naturalness, which shows the range of soundscape properties to be considered. They concluded that the capacity for psychological restoration is not unique to natural settings outside cities: properly designed urban places can significantly decrease negative emotions and perceived stress and can even increase positive emotions. Restoration depends on (acoustic) comfort and not exclusively on acoustic environments of low intensity. Thus, approaches that go beyond loudness or level are needed to study the impact of acoustic environments on humans in specific contexts. These requirements spur applications of the soundscape approach, which aims to encompass the perception and appraisal of acoustic environments in their entirety.

Soundscape methodology has provided important input for health-related research regarding noise and noise effects (see Lercher and Dzhambov, Chap. 9). As it is true in other applications, the influence of an acoustic environment is based on its associated contexts. Moreover, in health-related research, soundscape is considered through the lens of noise exposure and there is the expectation that adverse health effects can be prevented through "healthy soundscapes" designed within environmental planning. Agreement on sustainable methodological procedures is required for consistent application of the soundscape approach.

The soundscape standard ISO 12913 series provides support in three areas: ISO 12913-1:2014: Acoustics-Soundscape-Part 1. *Definition and conceptual framework*; ISO/TS 12913-2:2018: Acoustics-Soundscape-Part 2. *Data collection and reporting requirements*; and ISO/TS 12913-3:2019: Acoustics-Soundscape-Part 3. *Data analysis*. The platform for targeted measures is supported by a holistic approach in soundscape studies (see Schulte-Fortkamp and Jordan, Chap. 3).

Sound is a critical component of the environment that can give people a sense of place and time, but when an acoustic environment is unfamiliar, it adds to the anxiety of those who receive the sounds (Talebzadeh and Botteldooren 2022). For example, hospital sound levels have been increasing for decades not only due to the addition of more medical devices and the device's auditory alarm but also due to structural components of the physical environment, such as the nature of the flooring, doors, doorknobs, walls, and windows. Very seldom are calmness and

restfulness provided by the environment of the hospital room; instead, the hospital soundscape is loud with a cacophony of various activities. As a result, the hospital soundscape affects patients and staff negatively through a continuous burden of noise.

According to Busch-Vishniac et al. (2005) and Busch-Vishniac and Ryherd (2019), hospital soundscapes affect staff and patients, potentially increasing stress in the staff and anxiety in the patients. For some years now, various interventions have been discussed that might improve hospital soundscapes by including the implementation of quiet times, architectural designs that reduce reverberation, the addition of sound absorption, the use of earbuds or headphones, and the use of nature sounds to mask some less appreciated hospital sounds (see Busch-Vishniac and Ryherd, Chap. 10). As proposed in the soundscape standard ISO 12913 series, investigations are suggested to determine whether there is a direct link between patient medical outcomes and elements of the hospital soundscape that could confirm the success of specific interventions that can be scaled across a broad range of hospitals (Busch-Vishniac and Ryherd 2019).

In related work with patients suffering with dementia, Talebzadeh and Botteldooren (2022) explained how a personalized soundscape can support people by providing a pleasant acoustic environment. The development of that project has shown that a thoughtfully designed, familiar soundscape can reduce behavioral and psychological symptoms of dementia and also improve sleep quality.

1.4 Chapter Overview

Communication about noise management is required to guarantee that the specific components of soundscapes and human perceptions are equally relevant and seriously considered during the entire process of urban planning. The ISO standard 12931-1 (2014) on soundscape provides an important, and rigorous, distinction in the use of soundscape. Unfortunately, some individuals and groups, particularly planners, designers, laypersons, and even those primarily interested in management of indoor and outdoor environments through environmental noise control, use soundscape as a synonym for the physical acoustic environment. Thus, the chapters in this book are intended to help these people and other interested groups to better understand the full meaning of soundscape.

The need to accurately measure auditory perception and the challenges presented, especially outside of the laboratory, are discussed in Chap. 2 by André Fiebig: "Soundscape: A Construct of Human Perception." The author points out that further work is needed to develop sophisticated theoretical concepts that will allow researchers and practitioners to test the applicability of different methods to measure perception of a soundscape and to evaluate the validity of experimental outcomes.

In Chap. 3, "Soundscape: The Holistic Understanding of Acoustic Environment," Brigitte Schulte-Fortkamp and Pamela Jordan introduce soundscape as a construct

of human perception that factors in the entirety of an acoustic environment and the individual's responses to it. This stands in contrast to the acoustic environment alone, which is simply the composition of sound stimuli in an environment. The chapter begins by tracing the broad trajectory of soundscape studies to contextualize a holistic approach and concludes by highlighting various holistic research projects that sought to enhance the quality of acoustic environments and living situations.

Continuing with the importance of soundscape for quality of life in Chap. 4, "Soundscape and Urban Planning," Bennett M. Brooks considers how soundscape techniques can be applied to planning for communities. The author discusses urban planning as a key component in the process of actualizing the soundscape theory and implementing holistic improvements in the acoustical environment on a large scale. This chapter presents the basic concepts and principles of urban planning and urban design, which is the bridge between urban planning and architecture, regulation, smart growth, and a handbook toolbox for action.

In Chap. 5, "Architectural Soundscapes," Gary W. Siebein and Keely W. Siebein focus on the transformative steps that can be taken to translate soundscape data and analyses into the physical form of a building for which sound is conceived as a generator of form and is not necessarily a result of form nor of a series of elements added to the form. The links between architectural theories and soundscape theories are used to illustrate the basis of the elements and levels of the architectural soundscape design theory.

The importance of psychoacoustic data for a comprehensive evaluation of acoustic environments is considered in Chap. 6, "Psychoacoustics in Soundscape Research," by Klaus Genuit, Brigitte Schulte-Fortkamp, and André Fiebig. Moreover, a key point is made that humans perceive acoustic environments binaurally, which must be included in valid analyses because perception cannot be described adequately by simple sound level measurements. The authors argue that there is a critical need for aurally accurate measurements and psychoacoustic analyses with the distinct purpose of archiving and providing the ability to reexperience different acoustic environments.

In Chap. 7, "Measurements and Techniques in Soundscape Research," Giovanni Brambilla and André Fiebig describe techniques that include input from people who experience the environment under consideration, quantify various aspects of the acoustic environment, and evaluate the context of human interactions with the environment. Included in this survey of methodology are soundwalks, questionnaires, interviews, and recordings of sound that mimic the binaural way in which humans perceive sound, and how those methods are applied. In addition, the authors consider how international standards and technical specifications have led to a harmonization of data collection in soundscape investigations.

Dick Botteldooren, Bert De Coensel, Francesco Aletta, and Jian Kang discuss additional methodology in Chap. 8, "Triangulation as a Tool in Soundscape Research." Triangulating information has become an essential practice in soundscape studies. Indeed, the application of this analysis tool has important implications for soundscape data collection and also for theory development. Triangulation provides a useful lens through which research trends and future lines of

investigation can be identified. The authors reveal that very few scientific works in soundscape studies explicitly refer to triangulation as a reference framework, but the reality is that the concept underlies most soundscape research and practice.

In Chap. 9, "Soundscape and Health," Peter Lercher and Angel M. Dzhambov touch on the theory, practice, and assessment of the current state of research that relates the acoustic environment to quality of life and severe health effects. The authors describe an integrated approach to consider and characterize the acoustic environment and its associated physical, structural, social, and cultural contexts. They summarize the current status of health-related soundscape research and suggest further research needs. The authors clearly show that soundscape approaches have provided useful input for small scale environmental assessment and planning.

More specific applications of health-related soundscape studies follow in Chap. 10, "Soundscape in Hospitals," by Ilene Busch-Vishniac and Erica Ryherd. They point out that hospital soundscapes are challenging because there are many noise sources that contribute to the soundscape at all hours, and that this can negatively affect a vulnerable population. They also consider the specific sounds of the hospital soundscape and the physiological and emotional responses experienced by the people exposed to them. The practical uses of holistic tools and triangulation are revealed, building on topics discussed in Chaps. 3 and 8.

In the final chapter, André Fiebig and Brigitte Schulte-Fortkamp discuss "How to Put Soundscape into Practice." Soundscape is frequently regarded as an academic area of research, with studies of indicators and descriptors, old and new technologies, and new conceptual frameworks. On the one hand, there are still challenges in transferring the soundscape concept with its inherent holistic demand and its interdisciplinary foundation to real-world application. On the other hand, there are reservations from some noise consultants about applying new, evolving methods and approaches to deal with environmental noise. Therefore, the authors provide a guideline for practitioners on how to assess soundscape data, how to determine the need for interventions to preserve and/or improve a soundscape, and how to implement a soundscape design and/or intervention.

1.5 The Future of Soundscape Research

As the vital role of soundscape for the quality of life, well-being, and health has been recognized widely, researchers and practitioners have continued to work on guidelines to improve soundscapes effectively. An urban soundscape can promote the psychological restoration of its users; therefore, urban planning and architectural design need to focus on improving the perception of urban places, as summarized by Herranz-Pascual et al. (2019). Although this demand is almost self-evident, questions remain as to how the perception of acoustic environments can be improved: how do we evaluate the relationship between an acoustic environment and a specific context, and what are the mechanisms for improvement? Therefore, the collaborations with local experts, persons familiar with the soundscape due to their daily

routines related to the area, are needed to understand the site-specific perceptions of the acoustic environments, which are required to develop soundscape designs that reflect the needs of those local persons. Thus, urban development and planning need participatory processes and co-creation to be successful.

These developments to make the soundscape concept more popular are further promoted by the observations of the World Health Organization (WHO). In a review prepared in the framework of the WHO guidelines for environmental noise (Brown and Kamp 2017), different types of interventions were determined. In addition to the classical types, e.g., mitigation measures at the source or at the route/infrastructure level, the value of design and necessary communication between stakeholders were also considered. Accordingly, the authors of the review concluded that there is wide and increasing demand for innovative approaches that will decrease the negative impact of noise by using all types of interventions, including soundscape design. The utilization of the soundscape approach in the context of urban sound is still in its infancy and far more applications of the soundscape approach will lead to far more successful designs and interventions.

Acknowledgments The editors would like to thank Dr. Peggy Walton for working with us in editing this and many other chapters in the book. Dr. Walton did an exceptional job not only fixing grammar and formatting but also providing scholarly insight into ensuring that ideas were expressed clearly and organized in the most effective way.

Compliance with Ethics Requirements Brigitte Schulte-Fortkamp declares that she has no conflict of interest.

André Fiebig declares that he has no conflict of interest.

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